H. H. Scott
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The GENERAL RADIO EXPERIMENTER

VOL. VI. No. 12 MAY, 1932

ELECTRICAL COMMUNICATIONS TECHNIQUE AND ITS APPLICATIONS IN ALLIED FIELDS

NEW MEASURING INSTRUMENTS

OF the instruments described in the following pages of the EXPERIMENTER, three are of special interest to everyone interested in communication-frequency measurements. Both open new fields for investigation.

The vacuum-tube bridge, because it is capable of determining the dynamic characteristics of tubes over so wide a range, not only takes care of all the receiving-type tubes now in use, but will probably be able to handle all those developed for some time to come. The new circuit making possible the measurement of one characteristic without depending on other factors gives the new bridge a general utility wherever vacuum tubes are used.

The General Radio cathode-ray oscillograph is made available for obtaining the wave shape (amplitude-time characteristic) of a-c waves by the new sweep circuit. This device produces the necessary saw-tooth wave. Its frequency is controlled by the voltage being studied, hence the pattern remains stationary.

The output power meter will, of course, yield no information not previously obtainable with a decade resistance box, sensitive meter, a slide rule and a few moments of calculation. It does, however, save a considerable amount of time and equipment, and it makes easy a measurement that is often omitted because of the labor heretofore involved.

This new equipment will be on exhibition at the Trade Show of the Radio Manufacturers' Association in Chicago, May 23 to 26.

There our friends in the Chicago district, as well as the engineers of the radio industry, will have the opportunity of inspecting it.

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A BRIDGE FOR VACUUM-TUBE MEASUREMENTS

EVER since the introduction of the screen-grid tube there has been a quite definite need for more satisfactory methods of measuring the dynamic coefficients of vacuum tubes. More recently introduced types have added fresh difficulties, so that it is now desirable to measure not only very high amplification factors and high plate resistances but also very small and very large values of transconductance.

It has seemed desirable to develop methods which could be applied without modification to the measurement

All the dynamic characteristics of all low-power tubes can be investigated for an extremely wide range of values by the TYPE 561-A Vacuum-Tube Bridge

of extreme values of the tube parameters. It was felt furthermore that the new equipment should be applicable to determining any one of the three coefficients directly, so that it should never be necessary to make two measurements to obtain the quantity of interest.

In attempting to meet these severe requirements we have had to make radical changes from the old methods of measuring tube coefficients, with the result that the new equipment bears little resemblance to the conventional test apparatus.

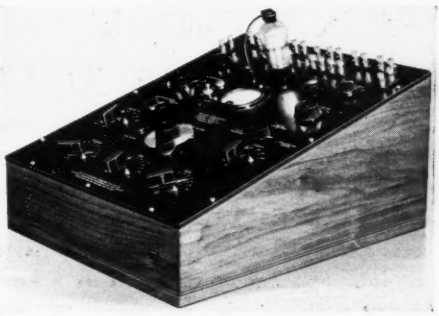
The photograph shows the panel arrangement of the new TYPE 561-A Vacuum-Tube Bridge. On the lower half of the panel, below the filament voltmeter, are located the controls of the measuring circuits. On the upper half are mounted four-, five-, and six-prong sockets, a transformer with associated controls for supplying a-c filament power, and the necessary terminals for battery connections.

No effort has been made to include a complete tube control panel with meters for measuring electrode voltages and currents. The requirements of different laboratories vary too widely in this respect to permit the construction of a generally acceptable arrangement. On the other hand a convenient means of controlling and reading the filament voltage is most important. A double-range thermal voltmeter is supplied for reading either a-c or d-c filament voltages up to 8 volts. The power transformer contained in the instrument is provided with a sufficient number of taps so that any a-c voltage in this range may be obtained without external connections.

It will be seen in the photograph that there are terminals for the supply voltages for the plate and for three grids. Provision is therefore made for the testing of the new pentodes in which the suppressor grid may be at a different potential from the cathode.

Special sockets may be plugged in when tubes having unusual bases or special base connections are to be tested. In other cases, such as in testing low-power transmitting tubes, it may be convenient to make the measurements when the tube is externally mounted with its control apparatus. The row of terminals just back of the sockets is provided for this purpose.

The measuring-circuit controls occupy the lower half of the panel. All three coefficients are determined by precisely the same procedure. The three-position switch at the right of the nameplate is turned to whichever quantity is desired, the multiplier switches are set at the appropriate value for the tube being tested, and balance is obtained by adjusting the three decade switches and the capacity-balancing condenser. At balance the decades read directly, to three significant figures, the quantity being measured.



Mounting the panel at an angle makes for easy reading when working at a table or at a laboratory bench

Negative values of all three coefficients may be measured by the same process as readily as positive values. The position of the switch at the left of the nameplate determines whether the quantity measured is positive or negative.

The multiplying and dividing switches control independent attenuators in the circuits supplying the a-c voltages on which the measurements depend. It was found necessary not only to design these circuits and their respective attenuators with particular care, but also to modify the fundamental scheme of the measurements so that the results would be independent of the ratio between the plate resistance and the plate-circuit impedance.

In a similar manner a new method of balancing capacitance currents has been adopted so that the measurements do not depend on the ratio between the plate resistance and the reactance of the stray capacitances. It has been found possible, therefore, to make accurate measurements of plate resistance when the reactance of the plate-filament capacitance is considerably less than the tube resistance.

It has not yet been possible for us to determine very closely the extreme values which can be measured with the new bridge. No difficulties have been encountered in measuring plate resistances of 20 megohms and amplification factors of several thousand. In the other direction measurements of mutual conductance down to a fraction of a micromho and of plate resistances down to 50 ohms are readily obtained. The range of the multiplier extends considerably beyond the limits given in both directions but special precautions may prove necessary to avoid external coupling between the oscillator and the amplifier if it is desired to extend further the useful operating range of the instrument. It is believed, however, that the TYPE 561-A Vacuum-Tube Bridge has a satisfactory margin over the present requirements of the vacuum-tube industry.

The necessary auxiliary equipment, in addition to the supply voltages for the plate and grids, includes a source of 1000-cps voltage, a sufficiently sensitive amplifier, and a pair of head telephones. Our TYPE 213 Audio Oscillator and TYPE 514-A Amplifier are recommended for this use.

—W. N. TUTTLE

A POWER METER WITH A WIDE IMPEDANCE RANGE

DETERMINING the power that one circuit can deliver to another is a most important communication measurement. The I.R.E. broadcast receiver tests, for instance, require that the loud-speaker be replaced by a load circuit with a resistance equal to that recommended for the output tube by its manufacturer. The receiver is then made to deliver 50 milliwatts into that load.

The introduction by General Radio of the output meter utilizing a rectifier-type voltmeter in conjunction with a constant-impedance multiplier made such power measurements considerably simpler. The output meter has had a wide acceptance in the field, in spite of

The method of using the output power meter can be seen from an inspection of the engraved scales. Full-scale deflection of meter corresponds to 50 milliwatts for a multiplier setting of "1"

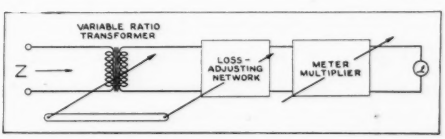
the fact that its resistance was limited to a single value: 4000 ohms at first. Later output meters for 8000 and for 20,000 ohms were made available.

Now, General Radio has developed an output meter of radically new design, in which the load resistance can be adjusted to cover a wide range, with the indicating element direct reading in milliwatts. Figure 1 shows the new TYPE 583-A Output Power Meter.

At the left are the two switches whose settings determine the resistance presented to a circuit connected across the two input terminals. The upper switch permits the selection of ten values which are approximately equally spaced on a logarithmic scale; the lower switch is an impedance multiplier. Hence, the impedance range of the instrument is from 2.5 ohms to 20,000 ohms.

At the right of the panel is a copper-oxide-rectifier voltmeter calibrated in milliwatts. Below it is the meter multiplier, which, when adjusted, makes the full-scale reading of the meter take successive values of 5, 50, 500, and 5000 milliwatts, respectively.

Obviously, the power scale can also be calibrated in decibels. This has been done, and both the meter and its multiplier carry auxiliary decibel scales



Schematic circuit diagram for the TYPE 583-A Output Power Meter

based on a zero reference level of one milliwatt. Readings may be expressed in terms of any other reference level by adding the proper correction term.

The secret of this unusual instrument is the variable-ratio transformer shown in the accompanying schematic diagram. This transformer must be a good approach to an ideal transformer. It must respond over a frequency range of 20 to 10,000 cycles per second, and it must be so constructed that the losses are as nearly constant as possible for every one of the ratio adjustments. A compensation network operated by the ratio changing switch corrects for small differences, so that for all ordinary purposes the transformer has a constant loss. The instrument always presents a nearly resistive impedance to an external circuit.

The principal application of this instrument will, of course, be in the testing of radio receivers. It will not only serve in the standard selectivity, sensitivity, band-width, and fidelity tests, but it can also be used for measuring with fair accuracy the output of the receiver for different frequencies when once the impedance characteristic of the speaker is known.

The output power meter is also useful for determining directly the output power characteristic of any circuit as a function of load impedance. It is useful when making measurements on oscillators, amplifiers, transformers, etc. Conversely, the internal output impedance of the circuit under test can be measured by determining the load impedance for which maximum power output is secured. Other uses will probably suggest themselves to the reader.

The price of the TYPE 583-A Output Power Meter is $85.00.

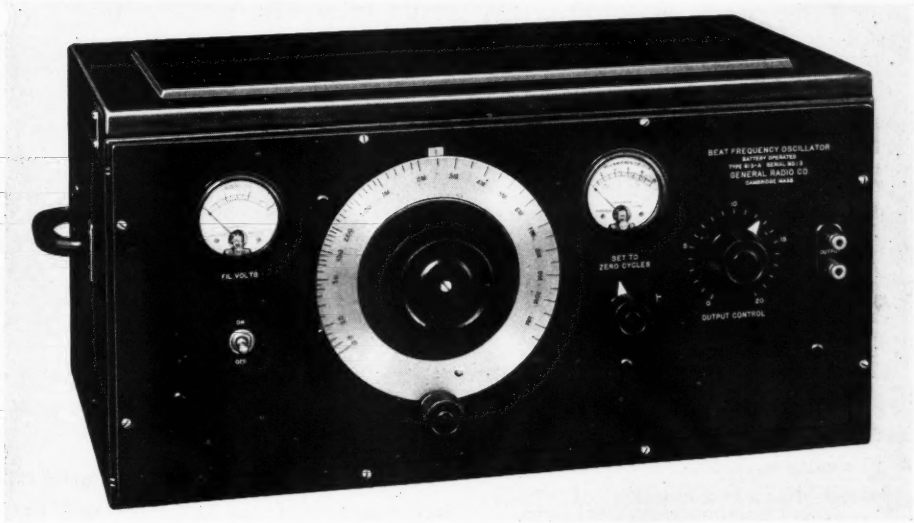
—JOHN D. CRAWFORD

A NEW BEAT-FREQUENCY OSCILLATOR

IN designing the TYPE 613-A Beat-Frequency Oscillator, our object has been to incorporate in a battery-operated type of instrument the desirable features of good waveform, frequency stability, and an open scale which are contained in the TYPE 513-B Beat-Frequency Oscillator (a-c operated) brought out last year.

The distinguishing characteristics of a beat-frequency oscillator are ability to maintain a constant output voltage over a wide frequency range and ability to cover a wide range of frequency with a single control. Two oscillators are used, one of fixed frequency, the other of variable frequency. The beat note between the two oscillators is passed through a detector and amplifier and becomes the output of the oscillator.

The fact that a wide frequency range is covered by a single control necessarily presents difficulty in obtaining an open and easily read scale. In the TYPE 613-A Beat-Frequency Oscillator, a straight-line-frequency condenser has been used, which results in a practically logarithmic scale spread around 270° of the dial. This scale is open and easily read at all points. Each instrument is



The TYPE 613-A Beat-Frequency Oscillator is operated from batteries inside the cabinet

individually calibrated and the dial individually engraved.

Some frequency drift is inevitable in a beat oscillator of any type. This arises from the fact that the output of the oscillator is obtained from the beat note between two oscillators of super-audio frequency. A change in the frequency of either oscillator will make a much larger percentage change in the beat frequency. Because of the practical impossibility of building component oscillators to be entirely free from frequency drift, some simple means of correcting for drifts must be provided. In the TYPE 613-A Beat-Frequency Oscillator a zero adjustment is furnished by means of which the two oscillators are set to zero beat when the main scale is set at zero. A milliammeter in the plate circuit serves as a beat indicator.

The instrument can be set to zero beat to within about a cycle and the scale is checked to within a cycle at all calibrated points so that the indicated frequency with the zero properly set is within two cycles at all settings of the dial.

The output has been carefully filtered so that spurious high frequencies are not present. The output characteristics may be summed up briefly as follows: Average voltage, 15 volts. The actual voltage does not depart from the average value by more than 20% over a range of 100 to 10,000 cycles. The harmonic content of the output is less than 2%. The range of calibration is 5 cycles to 10,000 cycles. The maximum power output occurs at a load of 5000 ohms and is 10 milliwatts.

The TYPE 613-A Beat-Frequency Oscillator requires three 230-type and one 231-type tubes. The battery requirements are two No. 6 dry cells and two 45-volt B blocks.

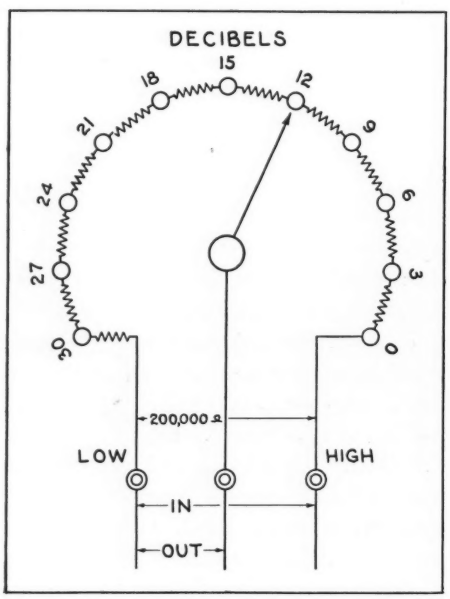
The price of the TYPE 613-A Beat-Frequency Oscillator is $210.00.

— CHARLES T. BURKE

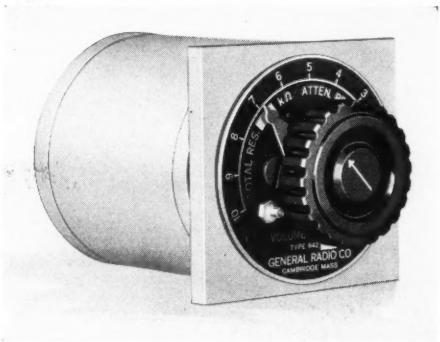
A 200,000-OHM GAIN CONTROL

IN many voice amplifier circuits a high-impedance gain-control potentiometer in the grid circuit is essential. The TYPE 642-D Volume Control is primarily designed as a high quality unit for the various types of amplifiers of this sort. It may be used in any standard voice amplifier circuit, connected across the secondary of the input or interstage coupling units.

The total resistance is 200,000 ohms, divided into ten equal steps of 3 decibels, providing a total attenuation of 30 decibels. Each resistance unit is adjusted to an accuracy of $\pm 1\%$, which gives attenuation ratios to within approximately 0.1 decibel. Because of its high impedance, accuracy of calibration, and compactness, its use as a multiplier for vacuum-tube voltmeters is also recommended. Although normally used in circuits drawing no current, a current of 4 milliamperes will not cause a temperature rise sufficient to change the rated accuracy of calibration.



The extremely high impedance of this volume control makes it ideal for use across the grid circuit of an amplifier



Each step on the TYPE 642-D Volume Control corresponds to an attenuation of 3 decibels

The frequency characteristic of any reasonably non-inductive potentiometer connected to the grid of a vacuum tube depends almost entirely upon the capacitance of this circuit. The TYPE 642 Volume Control can be worked into a capacitance of 40 micromicrofarads with an error of not more than 0.1 decibel at 10,000 cycles per second. Since the capacity of the usual vacuum tube and its socket at the grid terminal is less than 20 micromicrofarads, a negligible error will result at 10,000 cycles per second and the rated accuracy of 0.1 decibel will hold to approximately 20,000 cycles per second.

The amount of this error is also largely dependent upon the position of the contact arm and the figures mentioned above are for the worst conditions; that is, for attenuations of 3 or 6 decibels. The error is very much less at the higher values of attenuation.

The switch arm is constructed of four-leaf spring phosphor bronze, which provides for long wear and exceptionally low electrical contact noise. The construction is similar to that employed in the precision TYPE 602 Decade-Resistance Boxes. A cam-type detent is provided. This may be removed easily if smooth action is required.

The over-all dimensions are $3\frac{1}{16}$ inches diameter and $3\frac{1}{6}$ inches depth behind the panel.

The price is $25.00.

Modifications of the standard unit for different impedances and attenuations per step can be arranged on special order.

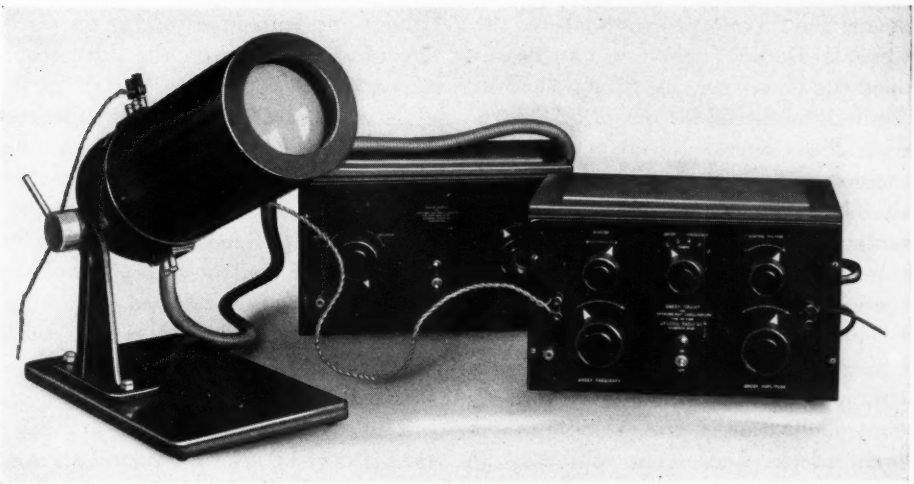
—ARTHUR E. THIESSEN

A LINEAR TIME AXIS FOR THE CATHODE-RAY OSCILLOGRAPH

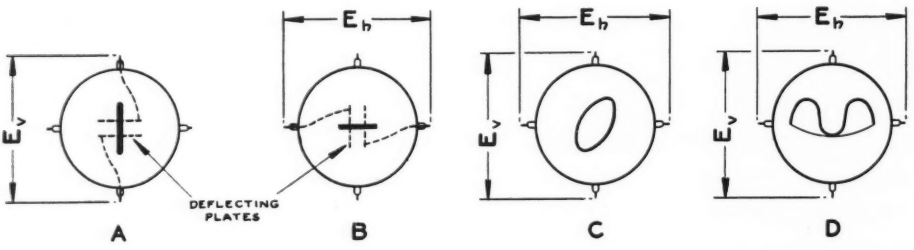
IN the past, use of the cathode-ray oscillograph has been considerably restricted due to the lack of an adequate means for obtaining the linear time axis that is necessary if wave shapes are to be observed. Although Lissajous figures are convenient in making frequency comparisons, they are in many cases entirely useless for examining the actual form of a wave.

Rotating mirrors and moving-film cameras have been used with varying degrees of success. The former, however, are limited to rather slow mirror speeds and the latter to photographic records.

The other common method for obtaining a linear time axis is the so-called sweep circuit. This consists of a means for generating a "saw-tooth" wave



The General Radio cathode-ray oscillograph. At the right is the sweep circuit and behind it the power-supply unit for the oscillograph tube



Here is what the sweep circuit does. Alternating voltages may be applied to the vertical deflecting plates (as in *A*) or to the horizontal plates (as in *B*). Pattern *C* results when E_v and E_h are applied simultaneously, the frequencies f_v and f_h being the same. If E_h is a "saw-tooth" wave derived from a sweep circuit and E_v is an alternating current wave to be examined, the wave shape of E_v appears in Pattern *D*

which, when applied to one pair of the oscillograph deflecting plates, produces a linear time axis. Commercial types of sweep circuits have, however, been restricted to operation over narrow ranges of frequency and amplitude. Furthermore, the problem of controlling the sweep circuit to keep in step with the waveform being observed, providing a stationary pattern on the oscillograph screen, has caused considerable trouble.

In order to overcome this limitation in the use of the cathode-ray oscillograph and provide a convenient means for waveform examination, the General Radio Company has developed the new TYPE 506 Sweep Circuit. While it is intended primarily for use with the General Radio cathode-ray oscillograph, it can also be used with similar oscillographs of other manufacture. It provides a practically linear time axis so that the waveform being observed is seen directly upon the fluorescent screen of the oscillograph.

A great advantage of this new sweep circuit is that its action may be easily controlled, that is, the periodic movement of the fluorescent spot may be made to coincide exactly with the frequency, or some submultiple of the frequency, of the wave being observed, thereby causing the pattern on the fluorescent screen to remain stationary. This makes careful examination of recurrent waveforms possible, and if desired, photographs may be taken of the patterns as they appear upon the screen.

The TYPE 506 Sweep Circuit has been carefully designed to provide a very high degree of control over the sweeping action. Separate adjustments are provided for changing the sweep frequency and length of sweep, as well as for regulating the amount of control voltage applied and adjusting the position of the pattern on the fluorescent screen.

Extreme care has been taken in the design of the control system so that no interference is transmitted from the sweep circuit itself back through the control circuits. Therefore, it is possible to obtain the control voltage from the same source as the observed wave without having the sweep circuit itself affect the form of the observed wave as seen upon the fluorescent screen.

The sweep circuit controls so readily that it may be used for examination of many types of transient phenomena. If a voice or music wave is impressed

upon it, it will lock into control at some low frequency or its submultiple in the voice or music wave. It is, accordingly, possible to study the waveform of any sustained note or sound, as well as to see many of the transients involved.

The principle of operation of the General Radio sweep circuit is very simple, but considerable care was required in constructing suitable equipment to carry out this principle satisfactorily. The circuit is, in effect, a modified form of relaxation oscillator. A condenser is charged at a constant current until the voltage across its terminals reaches a certain predetermined value. At this point, a special mercury-vapor tube breaks down and discharges the condenser practically instantaneously. The voltage across the terminals of the condenser is applied to the horizontal deflecting plates in the cathode-ray oscillograph, thus causing the fluorescent spot to travel in one direction at a practically constant velocity and then return almost immediately to its original position.

The voltage at which the discharge tube operates is controlled by a grid in the tube. This controls the amplitude of the sweep. The rate at which the condenser charges is controlled by the current limiting tube. This controls the velocity of the sweep. By introducing a small alternating voltage in series with the direct bias on the grid of the discharge tube, the sweep circuit may be made to lock in step with an alternating voltage near its natural frequency.

The General Radio TYPE 506 Sweep Circuit is completely a-c operated and carefully shielded. It is mounted in a small walnut cabinet of the same size and shape as the TYPE 496-B Power Supply Unit for the cathode-ray oscillograph.

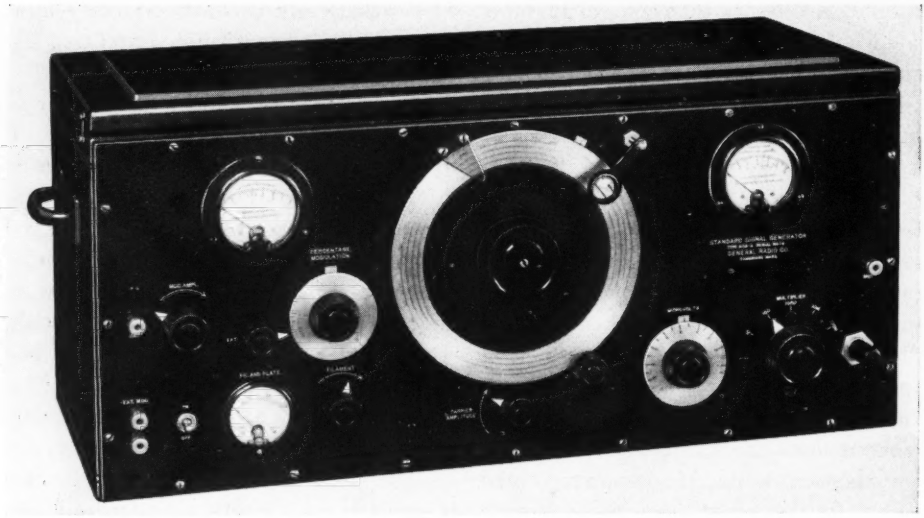
The price of the TYPE 506 Sweep Circuit is $160.00.— H. H. SCOTT

A STANDARD-SIGNAL GENERATOR FOR THE MEDIUM PRICE FIELD

THE development of radio receivers for operation at high frequencies has had its corollary in a demand for a satisfactory standard-signal generator to go to very high frequencies. A careful study of the problem has indicated that generators similar in general construction to those now employed can be used with suitable design modification at frequencies as high as 15 megacycles. It is believed work at higher frequencies will require a rather different design of signal generator and attenuator system from that now used.

The General Radio Company has had under development for the last year a new signal generator designed to meet the need for dependable behavior at high frequencies. The TYPE 603-A Standard-Signal Generator which will be shown at the Chicago Trade Show is the result of this development. This signal generator may be used over a frequency range extending from 100 kilocycles to 15 megacycles.

Over this range its performance is well within the limits of accuracy which we have become accustomed to



The main tuning control for the TYPE 603-A Standard-Signal Generator carries a dial with 600 divisions. The microscope at its right is an aid in making close settings; the triangular index at the left is for use with calibrations filled in with pencil by the user

expect from signal generators in the broadcast-frequency range. It is capable of modulation up to 90% at broadcast and higher frequencies. Internal modulation at 400 cycles is provided and provision is made for external modulation as well.

The new standard-signal generator will be used for the usual fidelity, sensitivity, and selectivity tests on receivers throughout the very wide frequency range for which it is adapted. It is also suitable for field-strength measurements throughout this wide range, since it is semi-portable and can easily be transferred in an automobile.

The new standard-signal generator has a number of interesting design features. The shield has been so modified without increase of leakage that it is not necessary to remove any screws in order to change coils. Immediate access to the coil compartment is obtained by raising the lid on the cabinet. Space for the extension coils is also provided inside of the cabinet. Leakage around the lid is avoided by a refrigerator-door type of construction in the shielding.

An interesting new type of attenuator and shield has been evolved. The usual resistance type of attenuator has been used with a modified construction as made necessary by the much higher frequencies involved. The attenuator is enclosed in a sectionized shield which makes possible very large attenuations even at frequencies at 15 megacycles without serious errors.

The controls are shown on the front of the panel. Those at the right govern the radio-frequency circuit, those at the left the modulation circuit. The carrier frequency is controlled by a large dial with slow-motion adjustment. This dial carries an accurately engraved scale of 600 divisions, spread around 270 degrees of its circumfer-

ence. The use of this dial in conjunction with a coil spread of approximately 2 to 1 in frequency makes possible direct calibration of the main frequency scale for use in selectivity and bandwidth determinations. Calibration charts are provided and they are of such size as to be read to the same accuracy as the dial scale.

Two additional convenience features will be noted on this dial: The magnifying glass over the main index greatly assists in setting and reading the scale. The secondary index, together with the space on the dial rim for extra scales, permits calibration of the instrument at special points to suit the user's requirements.

The carrier-frequency output voltage is controlled by the three adjustments in the lower right section of the panel. The carrier amplitude is adjusted, by means of the middle control, to a reference line on the right-hand meter. Maintaining this adjustment constant, the output is adjusted by means of the slide wire labeled *microvolts* and the multiplier. Continuous variation from one volt to ½ microvolt is provided. The output is taken off from the shielded plug terminals in the lower right edge of the cabinet.

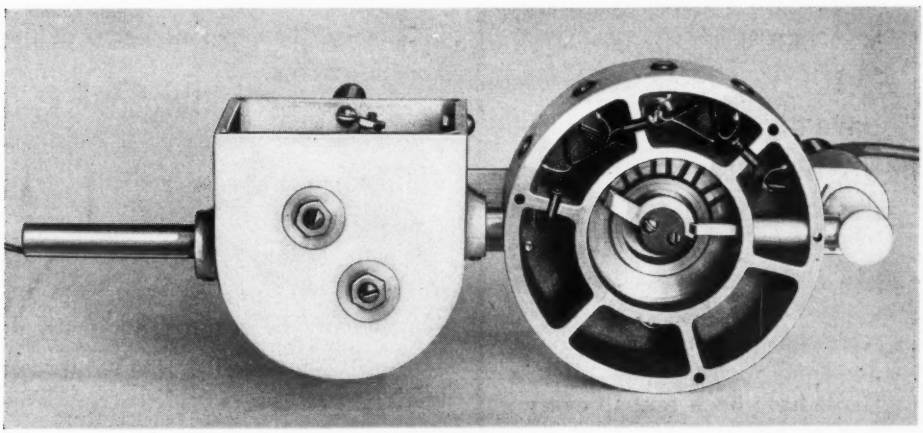
The modulation-control system is shown at the left. The meter indicates the modulation voltage and is set by means of the modulation amplitude control to a reference line. With the per cent modulation dial set at the desired modulation percentage, external modulation may be connected at the terminals indicated and controlled in the same manner.

In condensed form the performance characteristics, in the new signal generator, are as follows:

Frequency range: 100 kilocycles to 15 megacycles.

Accuracy of the output voltage at 1 microvolt: 3% in the broadcast range and below, 10% at 10 megacycles, and 12% at 15 megacycles.

The output voltage range permits continuous adjustment from



The attenuation system for the new standard-signal generator viewed from the back. The casting at the left contains the slide wire; the one at the right is the "mouse-trap-type" step-by-step attenuator

½ microvolt to one volt. Four hundred-cycle internal modulation is provided and the apparatus can be modulated with either internal or external modulation up to 90% at broadcast and higher frequencies.

The frequency modulation total swing does not exceed 200 cycles under the worst conditions in the broadcast band. At the RMA test frequencies it amounts to about 50 cycles.

The reaction of the attenuator on the carrier frequency is less than 150 cycles under all conditions.

The input impedance at the external modulation terminals is approximately 5000 ohms and a power of about 100 milliwatts is necessary to modulate the instrument to 30% throughout its range.

The radio-frequency output impedance is 10 ohms up to 10,000 microvolt setting.

The price of the TYPE 603 Standard-Signal Generator is $600.00. This includes the two calibrated inductors necessary for covering a frequency range of 420 to 1900 kilocycles, which includes the broadcast band.

—C. T. BURKE

Return the Card

Please don't forget to return the card that was clipped to page 1 of your copy of the EXPERIMENTER.*

It's the only way we have of keeping our mailing list correct and up to date.

*To distribute the load on our mailing department, some cards were sent with the April issue and some with this (May) issue. Cards have been sent to everyone except those whom we added to the list after April 1, 1932.

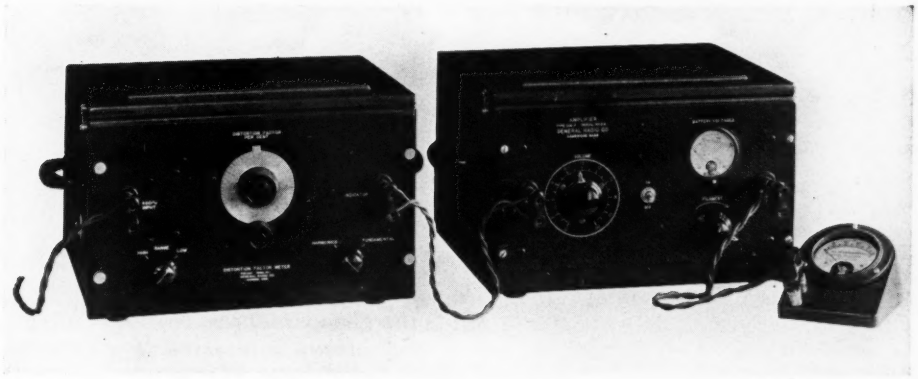
MISCELLANEOUS RECENT DEVELOPMENTS

The instruments illustrated on pages 15 and 16 are all recent developments. All except the new TYPE 654-A Voltage Divider have been described in some of the previous issues of the EXPERIMENTER.

The TYPE 654-A Voltage Divider is a combination of two sets of decade resistance units connected in series with the output voltage taken off across one set. When the resistance of the "output" unit is increased, the resistance of the other unit is simultaneously decreased to maintain constant total series resistance. This voltage divider performs the same function as the older TYPE 554 Voltage Divider it supersedes.

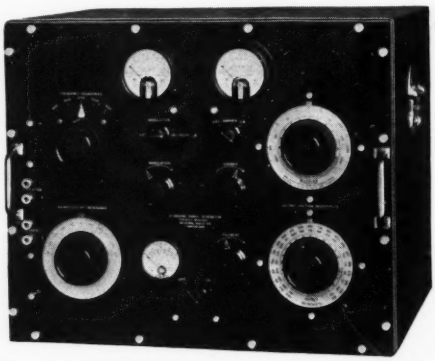
This precision voltage divider yields ratios of 0.001 to 1.000 in decade steps of 0.001. The total resistance presented by the input terminals always remains fixed at 10,000 ohms, since the resistance taken from any one unit is simultaneously added to its mate.

The price of the TYPE 654-A Decade Voltage Divider is $85.00



This equipment measures distortion factor. Left to right: TYPE 536-A Distortion-Factor Meter, $140.00; TYPE 514-A General-Purpose Amplifier, $70.00; and TYPE 488-HM Galvanometer, $30.00

TYPE 601-A Standard-Signal Generator is designed for production testing and airplane-receiver service work. Price $210.00



This standard-signal generator is recommended for laboratories where speed as well as precision are important factors. TYPE 600-A Standard-Signal Generator, $885.00

Freedom from noise, uniform attenuation, and low price are features of the TYPE 652 Volume Control. Price $12.50

TYPE 602 Decade-Resistance Boxes have submounted switches and are shielded against stray fields

THE GENERAL RADIO COMPANY mails the Experimenter, without charge, each month to engineers, scientists, and others interested in communication-frequency measurement and control problems. Please send requests for subscriptions and address-change notices to the

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